(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 959 522 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.11.1999 Bulletin 1999/47

(51) Int. Cl.[6]: **H01Q 3/38**, G01S 7/02

(21) Application number: **99107180.4**

(22) Date of filing: **13.04.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **19.05.1998 JP 13682598**

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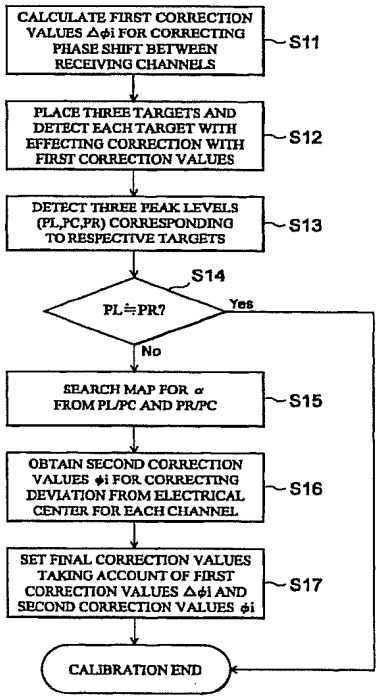
(54) Method for determining phase correction values in radar apparatus

(57) The present invention relates to a method for determining a phase correction value in a radar apparatus provided with an array antenna comprised of a plurality of antenna elements as a receiving antenna. The method for determining the phase correction value according to the present invention has a first step of obtaining a first correction value for each channel for correcting a phase shift between channels of the plural antenna elements, a second step of obtaining a second correction value for each channel for correcting a deviation between an electrical center direction and a front direction obtained with phase correction using the first correction values, and a third step of obtaining a final correction value for each channel from the first correction value and the second correction value, and the method determines such a phase correction value as to match the direction of 0° with the electrical center direction for each channel.

Fig.1



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third targets with respect to the first target will become equal to each other. Conversely, if the two directions disagree a difference will appear between the detection levels of the second and third targets. Therefore, an angular difference can be detected between the 0° direction and the electrical center direction from the level difference and phase correction values determined according to the angular difference can be used as the second correction values.

[0013] The present invention will be more fully understood from the detailed description given hereinbelow and the accompanying drawings, which are given by way of illustration only and are not to be considered as limiting the present invention.

[0014] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will be apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a flowchart to show an embodiment of the present invention;
Fig. 2 is a block diagram to show an example of the radar apparatus used in this embodiment;
Fig. 3 is a drawing to show the arrangement of the radar apparatus and the first target;
Fig. 4 is a drawing to show the arrangement of the radar apparatus and the first to third targets; and
Fig. 5 is a graph to show the detection result of the first to third targets by the radar apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Fig. 1 is a flowchart to show procedures in the method for determining the phase correction values in the radar apparatus as an embodiment of the present invention and Fig. 2 is a diagram to show an example of the radar apparatus to which the method for determining the phase correction values is applied.

[0017] The radar apparatus illustrated in Fig. 2 is an ordinary DBF radar apparatus which has a transmitting antenna 7 and a receiving antenna 1. The receiving antenna 1 is an array antenna comprised of n antenna elements 1-1 to 1-n. For each channel of antenna element there are a low-noise amplifier 2-1 to 2-n and a mixer 3-1 to 3-n provided, and in each mixer a received signal is mixed with a transmitted signal from an oscillator 8, whereupon the received signal is downconverted to a base-band signal. Each base-band signal in a corresponding channel is supplied via a filter 4-1 to 4-n to an A/D converter 5-1 to 5-n to be converted into a digital signal and the digital signal is supplied to a digital signal processing circuit (DSP circuit) 6.

[0018] The DSP circuit 6 can freely change the phase and amplitude by digital processing. A directional pattern of the antenna can be formed in an arbitrary direction and in an arbitrary shape by correcting the phase and amplitude of the digital received signal of each channel according to a certain rule by use of the function of the DSP circuit and further synthesizing the signals of all the channels. To form the directional pattern of the antenna by digital signal processing in this way is called digital beam forming (DBF).

[0019] During this DBF operation initial phase correction is carried out using the phase correction values determined by the present embodiment. The phase correction values are stored in a memory section in the DSP circuit 6.

[0020] The method for determining the phase correction values in the present embodiment will be described according to the flowchart of Fig. 1.

[0021] First, step S11 is to calculate the first correction values $\Delta\phi i$ ($i = 1, 2, \ldots, n$) for the respective channels for correcting the phase shifts between the receiving antenna channels.

[0022] Fig. 3 is a diagram for explaining a method employed in the calculation of the first correction values $\Delta\phi i$. As illustrated in Fig. 3, the first target 32 as a reference target is placed at the structural front (in the 0° direction) of the radar apparatus 31. The target 32 is desirably a point target like a corner reflector. The position of the target 32 can be an approximate front.

[0023] In this arrangement the radar apparatus is then actuated channel by channel for every antenna element. Supposing the distance from the radar apparatus 31 to the target 32 is, for example, approximately 10 m, waves radiated from the transmitting antenna, re-radiated from the target 32, and entering the respective antenna elements can be assumed to be parallel waves, and in this state the received signal of each channel is detected to obtain the phase and amplitude thereof.

[0024] After that, with respect to the reference at the phase and amplitude of a channel selected at random, for example, the channel of the antenna element located at the center of the receiving antenna, a correction value of each channel is determined so as to make the phase and amplitude of the other channels equal to those of the center channel. The phase correction values obtained at this time are the first correction values $\Delta\phi i$ ($i = 1, 2, \ldots, n$). In other words, such a phase correction value as to match the direction 34 to the first target 32 with the 0° direction is obtained for each channel and this phase correction value is used as the first correction value $\Delta\phi i$.

[0025] In Fig. 3, the direction indicated by numeral 33 represents the electrical center direction of the radar

areas are symmetric.

[0040] From the invention thus described, it will be obvious that the invention may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended for inclusion within the scope of the following claims.

[0041] The present invention relates to a method for determining a phase correction value in a radar apparatus provided with an array antenna comprised of a plurality of antenna elements as a receiving antenna. The method for determining the phase correction value according to the present invention has a first step of obtaining a first correction value for each channel for correcting a phase shift between channels of the plural antenna elements, a second step of obtaining a second correction value for each channel for correcting a deviation between an electrical center direction and a front direction obtained with phase correction using the first correction values, and a third step of obtaining a final correction value for each channel from the first correction value and the second correction value, and the method determines such a phase correction value as to match the direction of 0° with the electrical center direction for each channel.

Claims

1. A method for determining a phase correction value in a radar apparatus comprising an array antenna comprised of a plurality of antenna elements as a receiving antenna, said method comprising:

   a first step of obtaining a first correction value for each channel for correcting a phase shift between the channels of said plurality of antenna elements;
   a second step of obtaining a second correction value for each said channel for correcting a deviation between an electrical center direction and a front direction obtained with phase correction using said first correction values; and
   a third step of obtaining a final correction value for each said channel from said first correction value and second correction value.

2. The method according to Claim 1, wherein in said first step a first target is placed at a structural front of said radar apparatus, said radar apparatus is actuated channel by channel for said antenna elements, such a phase correction value as to match a direction of said first target with a direction of 0° is obtained for each said channel, and this phase correction value is used as said first correction value.

3. The method according to Claim 2, wherein in said second step second and third targets having an equal cross section of reflection to that of the first target are placed at an equal distance from the radar apparatus and at an equal spacing to said first target, said radar apparatus is actuated to detect said first to third targets with effecting the phase correction with said first correction values, and said second correction value for each channel is obtained based on detection levels of the respective targets.

Fig.2

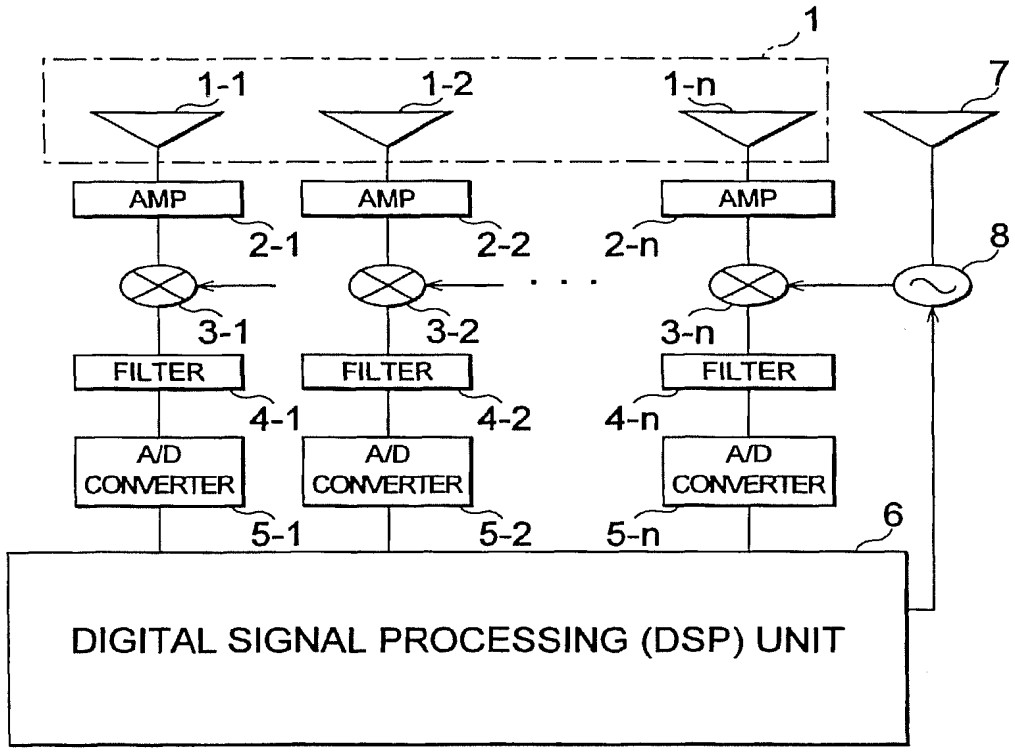
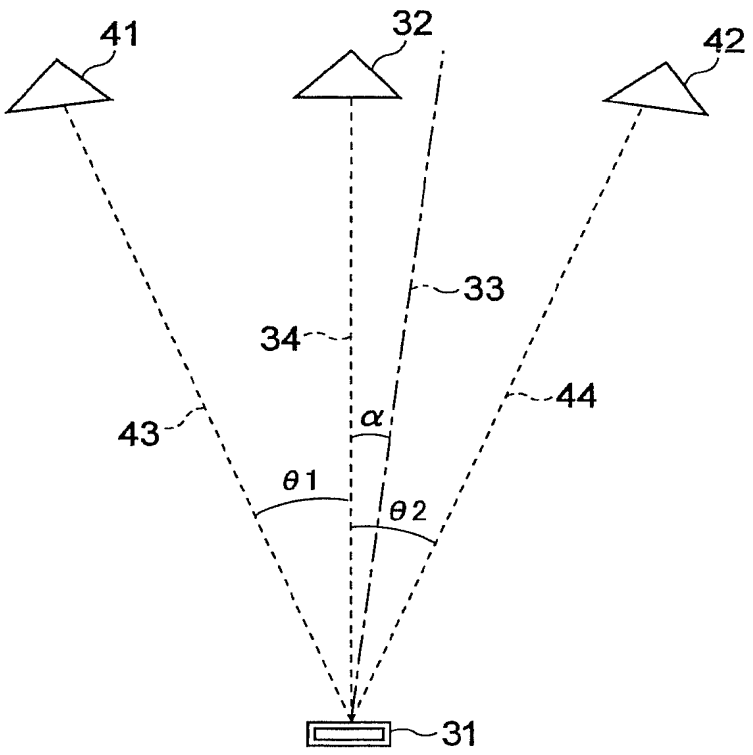


Fig.4



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EUROPEAN SEARCH REPORT

Application Number
EP 99 10 7180

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 097, no. 003, 31 March 1997 (1997-03-31) & JP 08 288734 A (NEC CORP), 1 November 1996 (1996-11-01) * abstract *	1,2	H01Q3/38 G01S7/02
A	EP 0 367 167 A (HUGHES AIRCRAFT COMP.) 9 May 1990 (1990-05-09) * abstract; claim 1 *	1	
A	US 5 623 270 A (KEMPKES ET AL.) 22 April 1997 (1997-04-22) * claim 1; figure 1 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H01Q
G01S

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	23 June 1999	FUSSY

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)